FIELD GUIDE - 3rd ANNUAL

SYMPOSIUM OF CARIBBEAN GEOLOGY

DEPARTMENT OF GEOLOGY
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EXCURSIONS B AND C - GEOLOGY OF THE CENTRAL IGNEOUS PROVINCE

The central igneous province is characterized by the exposure of large areas of plutonic rocks, mainly of Upper Cretaceous age, that have intruded a sequence of Lower and Upper Cretaceous stratified rocks.

Layered rocks of Lower Cretaceous age are exposed in the Barranquitas and Orocovis quddrangles (Briggs and Gelabert, 1962; Briggs, 1971) and in a wide area adjacent to the San Lorenzo Batholith (Fig. 1) (Berryhill and Glover, 1960; Rogers, 1979; Rogers et al., 1979; M'Gonigle, 1978). In the earlier stages of mapping of Puerto Rico these rocks were assigned the name "pre-Robles" rocks (e.g. Briggs and Gelabert, 1962) and in premonition of a better definition and correlation, differentiated with letters (e.g. A, B, C and D in Berryhill and Glover, 1960). More recently formal formation names were assigned (Briggs, 1969; M'Gonigle, 1978), but several formations are still only indicated with a letter.

The Lower Cretaceous rocks are overlain, possibly unconformably, by rocks of Upper Cretaceous age. This sequence includes volcaniclastic rocks, minor limestones, intercalated with volcanic flow rock and breccias (Berryhill, 1965; Berryhill and Glover, 1960; Briggs, 1969, 1971; Briggs and Gelabert, 1962; Mattson, 1968a, b; Nelson, 1966, 1967a, b; Nelson and Monroe, 1966; Pease and Briggs, 1960; Rogers, 1979).

The central province is characterized by volcanism throughout the Cretaceous. The chemistry of the Lower Cretaceous volcanic rocks suggests they belong to the island arc tholeiitic (Jakes and Gill, 1970) or primitive island arc suites (Donnelly and Rogers, 1980) and probably represent the early stages in the development of an island arc.

The Upper Cretaceous volcanic rocks all belong to a calcalkaline suite which can, on geochemical grounds, be distinguished from those of the Lower Cretaceous.

In the central province, which is unique in containing large volumes of Upper Cretaceous salic intrusives, igneous activity appears to have ceased by the late Cretaceous-early Tertiary. Uplift of this central province had already province had already progressed so far by the Eocene that plutonic rocks were exposed to erosion, as evidenced by granodiorite boulders in the Cibuco Formation (Nelson, 1967a).

The intrusives emplaced in the central igneous province are the Utuado Pluton in the west and the San Lorenzo Batholith in the east. Between these two are several smaller plutons (Caguas, Morovis, Ciales)(Fig. 1).

San Lorenzo batholith includes three principal units (Fig. 6) (Cox et al., 1976):

1. Diorite and gabbro bodies (xenoliths) generally within or close to the border]one of the batholith. (Age 78 Ma., probably a minimum age, since rocks were presumably reheated by younger events).

2. Granodiorite - quartz diorite unit, comprising about 75% of the batholith. (Average age 73.1 Ma.)

3. Quartz manzonite to quartz diorite unit, large outcrop near Punta Guayanís. (Average age 66 Ma.)

MIDDLE TERTIARY ROCKS OF THE SOUTHWESTERN IGNEOUS PROVINCE.

The Middle Tertiary rocks in southern Puerto Rico are only mapped in the Southwest igneous province. Although there is a lithologic resemblance between the Middle Tertiary rocks along the north and south coast they are very different. Deposition in the south may have begun earlier than in the north and may also have ended a little earlier. The rocks in southern Puerto Rico are intensely faulted, where as those in northern Puerto Rico are cut by very few faults. No exact correlation of strata in the north and the south has proved feasible (Monroe, 1980).

Monroe (1980) recognizes only three formations of Middle Tertiary age in southern Puerto Rico. At the bottom is the Juana Diaz Formation consisting of a very thick lenticular mass of intertonguing mudstone, conglomerate, limestone and a small amount of unconsolidated sand and lignite. The Juana Diaz Formation is overlain unconformably by the Ponce Limestone. The third formation is the Guanajibo Formation that is approximately equivalent in age to the Ponce Limestone.

Juana Diaz

The Juana Diaz Formation shows a varied lithologic character from terruginous boulder conglomerates to deep water limestone turbidites. The formation ranges in age from Oligocene to Lower Miocene (Seiglie and Moussa, 1970) or to Middle Miocene, (Monroe, 1980). Monroe (1980) includes one unit that is considered by Seiglie and Moussa (1970) to belong to the overlying Ponce Limestone. At most places the Juana Diaz Formation is in fault contact with older rocks which range in age from Cretaceous to Eocene. Where the depositional contact can be observed it rests on an eroded and highly irregular surface of older rocks. The top of the Juana Diaz Formation was truncated by erosion before the Ponce Limestone was deposited (Monroe, 1980).

The origin of the Juana Diaz Formation passes several problems. Based on its lithologic character such as thin-bedded and crossbedded carbonaceous sand, conglomerate and carbonaceous clay, reef limestone and coral heads. Monroe (1980) interprets the Juana Diaz Formation as deposited in near shore shallow water. Seiglie and Moussa (1970) and Moussa (1977) more strictly define the Juana Diaz Formation as deposited in deep (· 300m) water. They base their conclusion on the presence of planktonic foraminifers in both the clastic lower part and the calcareous upper part of the Juana Diaz Formation. They argue that although the bioclastic limestones of the Juana Diaz Formation contain faunal assemblages characteristic of shallow waters, the presence of plantonic foraminifers, the clastic nature and interbedded pelagic mudstones are evidence that the limestones are redeposited. Moussa (1977) recognized graded bedding and flute molds in some beds suggesting transport from shelf to deep water by turbidity currents. Moreover he describes a shallow water limestone block enclosed in pelagic mudstone, when he interprets as a gravity slide block. The USGS include all Oligocene-Miocene limestone and clastic rocks in the Juana Diaz Formation irrespective of their mode of origin.

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EXCURSION B: Plutonic Rocks of the Central Igneous Province - The San Lorenzo Batholith

Leave San Lorenzo on Route 183 to Las Piedras then take Route 30 toward Humacao and then Route 3 south-bound to Yabucoa. Take Route 906 to Playa Guayanés.

STOP 1. Punta Guayanés member.

The shoreline outcrops expose the contact zone between granodiorite and tonalite.

Return to Yabucoa on 906 to Parcelas Comunas and then on Route 3 to Yabucoa. Take Route 901 along the coast to Puerto Maunabo.

STOP 2. Punta Tuna

The exposures are layered meta-sediments at the contact with granodiorite. Extremely large xenoliths of meta-sediment occur in the granodiorite.

Return on Route 901 to Km. 2.25. Past the school turn right through a parking lot to an asphalt road and continue to the beach.

STOP 3. Granadiorite and Alluvium.

Granadiorite with some very large zanoliths is overlain by alluvium containing tonalite and diorite.

Return to San Lorenzo via Route 901 to Puerto Maunabo then

Route 3 towards Yabucoa and Humacao. Then take Route 30 towards Caguas to Route 183 and San Lorenzo.

EXCURSION C. The Early and Late Cretaceous Rocks of the Central Igneous Province and the Tertiary Sediments of the Southwestern Igneous Province.

From San Lorenzo take 183 to Caguas and the Route 52 (Autopista) to Cayey.

Route 52, Km. 42.8 - 43.1. STOP 1. Robles formation.

An interesting and diverse outcrop of sedimentary and igneous rocks of the late Cretaceous Robles formation (figure 7). The section starts on the north in a volcanic breccia with a green chloritic matrix. The breccia is followed by a feldspar porphyry which is intruded by microdiorite with chilled margins. A fault separates the porphyry from a sequence of volcanoclastic sediments. The dark color of the rocks and common iron staining (weathered pyrite) suggest they are carbonaceous. Scattered blocks of fossiliferous limestone and some folding occur in the sedimentary rocks. The outcrop ends in a light colored igneous rock which is either in intrusive or fault contact with the sedimentary rocks.

Route 2, Km. 44.2. Hydrothermally altered volcanic rocks.

This zone of hydrothermal alteration may be related to the early Cretaceous base-metal-vein deposit of Cerro Anispa.

Route 52, Km. 49.7. STOP 2. Jibaro Monument.

The surrounding rocks are early Cretaceous volcaniclastic rocks and sediments. The late Cretaceous Las Tetas lavas crop-out to the northwest, in a conspicuous pair of bald knobs bearing the same name.

Route 52, Km. 53.4. STOP 3. Formation C.

The outcrop is composed of volcanic and volcaniclastic rocks mapped as early Cretaceous. The low ridges in the valley below are the eastern extension of the Eocene belt.

Route 52, Km. 59.8-60.9. STOP 4. Robles formation.

The outcrop exposes spectacular pillows and other sub-marine lava flow structures. The basaltic rocks are mapped as the Lapa Lava member of the late Cretaceous Robles formation.

Route 52, Km. 68.3. STOP 5. Cuevas limestone and Coamo formation?

The outcrop consists of folded limestone on the north east and limestone and purple volcaniclastic blocks in a bedded sandy matrix in the southwestern part. The area is mapped as Cuevas limestone (Eocene) and Coamo formation (late Cretaceous) (figure 8).

Route 52, Km. 82.9. STOP 6. Raspaldo formation?

Interbedded sandstones and mudstones containing sedimentary structures typical of turbidite deposits. The sediments probably belong to the Eocene Raspaldo formation (figure 8).

Route 52, Km. 87.3 - 86.8. STOP 7. Juana Diaz formation.

Coarse conglomerates interlayered with red colored finer grained sediments. Bottom contacts of the conglomerates are scoured. The unit is mapped as part of the lower clastic member of the Oligocene Juana Diaz formation.

Route 52, Km. 97.3. STOP 8. Juana Diaz formation.

A limestone mass of about 115m wide and 15m thick occurs within the pelagic claystone of the Juana Diaz Formation. The limestone is made up entirely of biogenic material, predominantly the calcareous tests of the orbitoid foraminifer Lepidocyclina undosa. Algae are an important constituent of the upper one third of the limestone. (Moussa, 1977).

Moussa (1977) interprets this limestone mass as a submarine slide block, formed in shallow water, displaced into deep waters. His arguments are as follows:

- Shallow water limestone is enclosed within sediments with pelagic foraminifers.

- The shallow water sediments occur several kilometers from the nearest reef build-up.

- A tongue of soft mud intrudes the limestone block.

- Mudstones are folded east of limestone block. The mudstone on the eastern edge of limestone appears to dip eastward, but several meters farther east these same beds are dipping westward, which is the general dipp of mudstone in the area.

Monroe (1980, p. 71) interprets the east edge of the block as a landward edge of a reef or possibly a fault that formed during deposition of the sandy shale.

Return on Route 52 to Ponce, then Route 2 to Mayaguez.

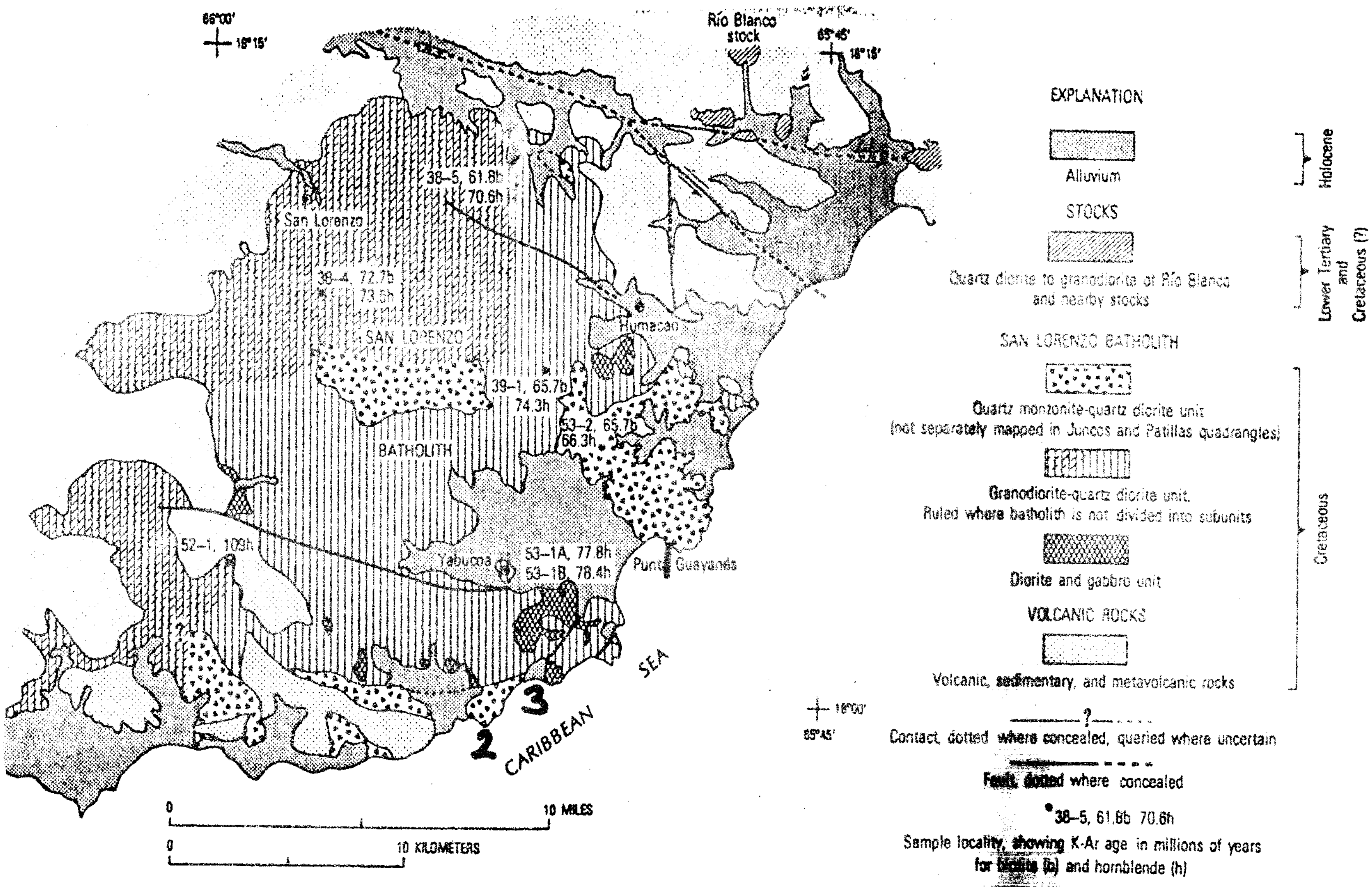


Figure 6. Generalized geologic map of the San Lorenzo batholith. (Cox et al., 1977)

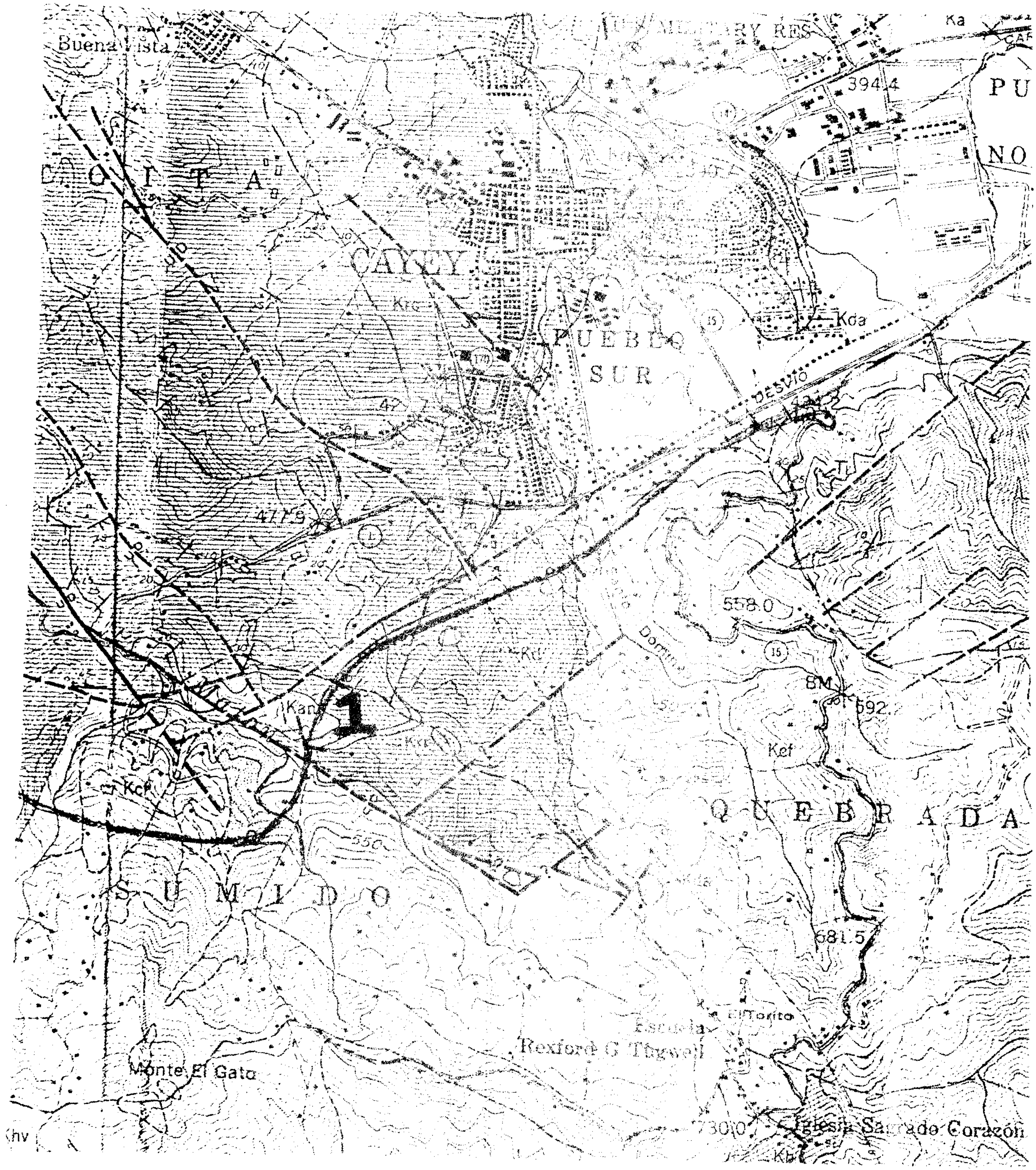
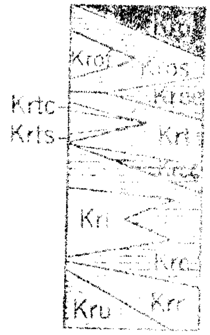


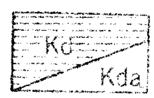
Figure 7A. Detail geological map. Cayey quadrangle.

(Berryhill and Glover, 1960).



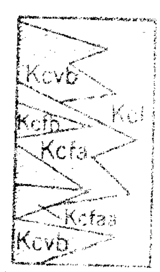
Robles formation

Consists chiefly of lapilli tuff, limestone, volcanic siltstone and sandstone, lenses of conglomerate, and basaltic andesite flows; includes unit of limestone, Krol; *thin andesite flow,* Krof; *Collao member which consists chiefly of siltstone,* Kros, *but includes lenses of conglomerate,* Kroc; *Las Tetas lava member,* Krt, *including tongues of conglomerate,* Krtc, *and siltstone,* Krts; *Cayey siltstone member,* Krc, *including at top a lenticular bed of conglomerate,* Krcc; *Lapa lava member,* Krl, *which is intertongued with the Cayey siltstone member; Río Matón limestone member,* Krr, *and unit of lapilli tuff,* Kru



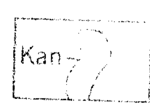
Formation D

Predominantly andesite flows; includes locally in lower part bedded, tuffaceous calcareous sandstone and breccia, and, locally at base, Aguas Buenas limestone member, Kda. *South of Cayey formation characterized by reddish color*



Formation C

Interstratified massive andesite flows, Kcf; *flow breccias,* Kcfb; *and massive volcanic breccias,* Kcvb; *includes in southwestern part of quadrangle several extensive amygdaloidal andesitic flows,* Kcfa, *one group of which is characterized by aphanitic texture,* Kcfaa



Andesite

Dikes and small stock of porphyritic andesite consisting of phenocrysts of plagioclase and pyroxene in aphanitic groundmass

Figure 7B. Legend of Figure 7A.

Figure 8A. Detail geologic map Rio Descalabrado Quadrangle. (Glover and Mattson, 1973).

UNCONFORMITY

TERTIARY

Middle Eocene

Jacaguas Group

Tds
Tdl
Tds
Tdc

Río Descalabrado Formation

Dacitic and andesitic tuff and mudstone, Tds*; minor thin limestone lenses,* Tdl*; and rare pebble to cobble conglomerate,* Tdc*. Mostly thin to medium bedded; common graded bedding and small-scale crossbedding. Tuffaceous strata are commonly greenish gray to light olive gray plankton-rich microfauna. Greater than 500 m thick*

Tgb

Guayo Formation

Conglomeratic lapilli tuff, tuff, and minor mudstone, thick bedded and massive. Interfingers with Rio Descalabrado Formation. Greater than 200 m thick

Cuevas Limestone

Algal limestone (biomicrite) with an intact framework of coarse to fine fragments of calcareous red algae; thick-bedded or massive, less commonly thin bedded; nearly white but the basal impure facies may be grayish red. 35 m thick

Lower Paleocene to lower Eocene

Tlpt
Tlps
Tlpl
Tlpt

Los Puertos Formation

Tuff breccia and conglomeratic tuff breccia, Tlpt*; tuff,* Tlps*; minor limestone,* Tlpl*. Mostly pyroxene and feldspathic-andesite in massive to thick-bedded units; grayish-red-purple to pale-brown. Interbeds of plankton-bearing tuffaceous mudstone. Some reworked rudistids. Grades laterally into the Raspaldo Formation. Base concealed by faulting. Greater than 350 m thick*

Trs
Trl
Trs

Raspaldo Formation

Dacitic and andesitic tuff and mudstone, Trs*; minor limestone,* Trl*; and minor conglomerate, (not mapped). Tuff and mudstone are light olive gray to yellowish gray; thin- to medium-bedded, with common graded bedding and some small-scale crossbedding. The fauna is plankton-rich. Rudistids reworked from older formations are rare to common. Greater than 600 m thick*

Figure 8B. Legend of Figure 8A.

Upper Cretaceous to Eocene

Maestrichtian

TKm
TKmt
TKm

Miramar Formation

Coarse, red volcanic-wacke conglomerate with abundant reworked dacite tuff, TKm; *medium- to thick-bedded; contains an oyster-rich limestone at and near the tops,* TKmit. *About 700 m thick*

UNCONFORMITY

Upper Cretaceous

Campanian or Maestrichtian

Kcot Kcof

Coamo Formation

Massive to thick-bedded coarse pyroxene-andesite tuff breccia and tuff, Kcot; *dark-gray to reddish- and greenish-black predominate, pyroxene-andesite lava,* Kcof. *Greater than 1500 m thick*

Kl

Limestone in Esmeralda fault breccia (mb)

Upper Santonian(?), Campanian, Maestrichtian(?)

Kmab
Kmal
Kmau Kmas
Kmaa
Kmad

Maravillas Formation

Hornblende-rich, andesitic, marine-deposited lapilli tuff, Kmab *and San Diego Member,* Kmad; *tuff and tuffaceous mudstone,* Kmas; *Santa Ana Limestone Member,* Kmaa *and a younger limestone,* Kmal. *Maravillas Formation undivided,* Kmau. *All coarse pyroclastic units tend to be massive and thick bedded. Abundant macrofossils, planktonic and benthonic microfossils. 460 to 1400 m thick*

Santonian

Kcc
Kc
Kcs

Cariblanco Formation

Coarse bimodal conglomerate of well-rounded pebbles; cobbles, and boulders of pyroxene-andesite lava and dacite welded tuff, Kcc; *coarsely conglomeratic rocks grade into fine conglomerate and reworked tuff and tuffaceous mudstone,* Kcs; *minor limestone,* Kcl. *Cariblanco undivided,* Kc. *Most rocks are drab shades of green and gray. 800 to 1000 m thick*

Ka

Achiote Conglomerate

Red tuffaceous-wacke conglomerate and tuffaceous wacke. Very well rounded cobbles and boulders of pyroxene-andesite lava and dacite welded tuff. Medium- to thick-bedded. Interfingers with the Cariblanco Formation. About 800 m thick

CRETACEOUS

Figure 8C. Legend of Figure 8A.

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